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THE DISTRIBUTION AND ECOLOGY OF *TEXOSPORIUM* IN SOUTHERN CALIFORNIA

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Abstract

New populations and range extensions of *Texosporium sancti-jacobi* are reported from southern California, which include the first known record of the species from Ventura County. The preferred habitat of *Texosporium* is the mosaic of bare-soil patches associated with undisturbed open shrublands that are sparsely vegetated with native forbs, are free of exotic weeds, and support a well-developed biological soil crust. These "open-habitat soils" must become a focus of conservation activities if *Texosporium,* other rare crust organisms, small native annual dicots, and many insects are to persist in southern California.

Texosporium sancti-jacobi (Tuck.) Nádv. (woven spore lichen) is a rare lichen that forms inconspicuous white to grayish crusts on soil, organic matter including old rabbit pellets, small twigs in soil duff, and decaying bunch grass stubble (McCune and Rosentreter 1992), basal stems of *Selaginella,* and on other lichens. *Texosporium* is a monotypic genus. It is the only known lichen that produces spores with a thick coat that is analogous to the protective coverings that have evolved in the seed plants (McCune and Rosentreter 1992), which makes it valuable for the study of evolutionary processes (Tibell and van Hofsten 1968). *Texosporium* is endemic to western North America. It is known from only a few extremely small and localized populations from southern Idaho, central Oregon (north of Bend, OR), Benton and Klickitat counties in south-central Washington, and central and southern California (Ponzetti 1999). *Texosporium* (cited as *Cyphelium sancti-jacobi* [Tuck.] Zahlbr.) has been reported from Mexico (Imshaug 1956), but has not been confirmed. These sites are all in open habitats with arid climates.

Texosporium is listed as critically endangered globally by the International Association of Lichenologists (Thor 1996). Additionally, it is an Idaho Native Plant Society Priority 1 Species (Idaho Native Plant Society 1991), is critically imperiled in Oregon (Oregon Natural Heritage Program 2001), is considered threatened by the California Department of Fish and Game (2003), and has been proposed for rare status by the California Lichen Society (Magney 1999).

Until recently, *Texosporium* was known from only a few locations in California, the historic type locality in San Diego County reported by Tuckerman in 1883 and the Pinnacles National Monument in central California (McCune and Rosentreter 1992); and in the southern part of the State from the Aliso Canyon/Cuyama Valley area of Santa Barbara County, on San Clemente Island and Santa Catalina Island, in the San Diego area from San Clemente Canyon (Bratt 2002), and western Riverside County (Riefner et al. 2002). Expanding urbanization has likely extirpated most San Diego County populations, including Kearny Mesa (Magney 1999; Bratt 2002), but remnants of historical populations may be extant (Ponzetti 1999).

Specimens Seen

Texosporium sancti-jacobi (Tuck.) Nádv. (Ascomycetes, Caliciales)—Riverside Co., Gavilan Hills, Hartford Springs Park, UTM 11 0466937E 3741002N (NAD 83), rare on old twigs in soil duff and on rabbit dung on decomposed granitic soils, chamise chaparral, 588 m (1929′), 12 December 2002, *Riefner 02-516* (WIS); S of Sage, Wilson Valley, Sage Road N of Wilson Valley Road, UTM 11 0506287E 3715779N (NAD 83), rare on soil with biological crust organisms, chamise chaparral, 707 m (2320′), 12 December 2002, *Riefner 02-523* (WIS); San Diego Co., La Jolla, end of Town Center Drive off Eastgate Mall Road, E of I-5 Freeway, UTM 11 0479625E 3638675N (NAD 83), rare on soil with biological crust organisms and on old twigs in soil duff, coastal sage scrub, 111 m (363′) *Rosentreter 14,612* (Herb. Rosentreter); Kearny Mesa, near San Diego Spectrum Mall off Clairemont Mesa Road, UTM 11 0488208E 3631916N (NAD 27), rare on soil with *Selaginella cinerascens* Maxon and bryophytes and on rabbit dung, remnant mima mound—vernal pool topography, 122 m (400′), 16 December 2001, *Riefner 01-778* (ASU); S of Soledad Canyon, E of I-5 Freeway, W side of 805-Freeway off Eastgate Mall Road, UTM 11 0480739E 3638316N (NAD 27), rare on soil with

Selaginella cinerascens and on rabbit dung, chaparral, 122 m (400′), 16 December 2001, *Riefner 01-882* (ASU, WIS); Tierrasanta, Mission Trails Regional Park, E end of Clairemont Mesa Road, UTM 11 0493884E 3632573N (NAD 27), rare on rabbit dung over *Selaginella cinerascens,* chaparral, 244 m (800′), 22 February 2003, *Riefner 03-108* (Herb. Rosentreter, UCR); Shepherd Canyon, Mission Trails Regional Park, UTM 11 0493290E 3633240N (NAD 27), rare on rabbit dung over *Selaginella cinerascens* near vernal pool, coastal sage scrub, 251 m (825′), 22 February 2003, *Riefner 03-109* (ASU, UCR); Mission Gorge near Cowles Mountain County Park, UTM 11 0497495E 3630676N (NAD 83), rare on rabbit dung and twigs in soil duff, chamise chaparral, 333 m (1091′), 22 February 2003, *Riefner 03-122* (WIS); Del Mar, N of Torrey Pines State Park near Del Mar High School, Del Mar Scenic Pkwy., UTM 11 0476538E 3644799N (NAD 27), rare on rabbit dung among ironstone concretions and forbs, chamise chaparral, 114 m (375′), 8 September 2002, *Riefner 02-219* (Herb. Rosentreter, UCR, WIS); Del Mar, Crest Canyon Preserve, Durango Road, UTM 11 0476394E 3644796N (NAD 27), rare on old twigs in soil duff, chamise chaparral (385′), 28 July 2002, *Riefner 02-114* (Herb. Rosentreter, ASU); La Jolla, W of I-5 Freeway, S of Genesee Road and John Jay Hopkins Drive at UC San Diego open space park, UTM 11 0478576E 3637666N (NAD 83), rare on rabbit dung and old twigs in soil duff, chamise chaparral, 121 m (396′), 28 July 2002, *Riefner 02-117* (Herb. Rosentreter, ASU); Soledad Canyon, N of New Miramar Road and W off Eastgate Drive, E of I-805 Freeway, UTM 11 0481610E 3638680N (NAD 83), rare on soil with *Selaginella cinerascens* and bryophytes, mixed chaparral, 109 m (358′), 1 March 2003, *Riefner 03-56* (Herb. Rosentreter, ASU, UCR, WIS); Del Mar, Del Mar Mesa, N side of Los Peñasquitos Canyon at power line right-of-way, UTM 11 0482931E 3643885N (NAD 83), rare on twigs in soil duff and on rabbit dung, chamise chaparral, 129 m (423′), 19 April 2003, *Riefner 03-217* (ASU, WIS); La Jolla, N of end of Town Center Drive off Eastgate Mall Road, E of I-5 Freeway, UTM 11 0479642E 3638975N (NAD 83), locally common on rabbit dung and on old twigs in *Cladonia* and *Selaginella* mats, rare on wood rat dung and on soil, coastal sage scrub, 108 m (353′) *Riefner 03-315* (Herb. Rosentreter); Ventura Co., Western Santa Monica Mountains, S of Camarillo, Long Grade Canyon along Portrero Road S of Hueneme Road, UTM 11 0312767E 3781632N (NAD 83), very rare on soil with cryptogamic crust organisms, on rabbit dung, and on old twigs in soil duff with *Selaginella bigelovii,* coastal sage scrub over volcanic rock, 106 m (347′), 29 March 2003, *Riefner 03-207* (Herb. Rosentreter).

In San Diego County, the first author rediscovered two historic populations of uncertain status discussed by Ponzetti (1999); the *Weber & Santesson* site on Kearny Mesa (Clairemont Mesa Road near the General Dynamics facility, now the San Diego Spectrum complex), and the *Weber & McCoy* population from clay hills north of Torrey Pines State Park at Del Mar, and we report several populations that are new records for the county (Fig. 1). We also report the first known population of *Texosporium* from Ventura County, and can add two other sites to its known range in western Riverside County. Although widespread, these populations are extremely small localized sites and are susceptible to local extinction owing to changes in land use patterns, expanding urbanization, accelerated erosion, trampling by heavy foot-traffic or crushing by off-road vehicles, and to habitat alterations by fire. Further, the small size of these populations, poor competitive abilities with exotic grasses, and restricted sunny micro-sites within undisturbed open ecosystems, render *Texosporium* highly vulnerable.

In the southern California climate, preferred habitat of *Texosporium* is the mosaic of bare-soil patches and herbaceous-plant dominated microsites associated with undisturbed open shrublands. We propose that the term "open-habitat soils" should be used to describe these natural openings or gaps in the arid vegetation that are not maintained by fire. Open-habitat soils are sparsely vegetated with native forbs and scattered bunch grasses, are free of exotic weeds, and support a well-developed biological soil crust. The biological soil crusts help to maintain these open habitats by inhibiting large-seeded exotic plants from germinating (Belnap et al. 2001). The small vascular plant species and cryptogams adapted to these open sites are usually different from those found in disturbance-created open areas in the same region. The open- or clumped-vegetation pattern of many arid systems is often used as a measure of a healthy landscape (Tongway 1994). The presence of biological soil crusts in these open ecosystems can often indicate if the site appears barren but is biologically productive and functioning ecologically, or if the soils are barren, devoid of biological crusts and weedy, and not functioning as an open habitat.

The habitats of *Texosporium* share a number of site-specific characteristics: landforms characteristic of remnant, stable, high-level geomorphic surfaces that support weathered, well-developed soils marked by abrupt argillic (claypan) and cemented silcrete (duripan) horizons or shallow soils over bedrock that restrict deep-rooted plants and promote open environments (Edwards et al. 1970; Knecht 1971; Bowman 1973); a surface layer of well-drained, fine- to coarse-grained soils developed on nearly level terrain; relatively low anthropogenic soil surface disturbance; and physical properties, i.e., duripan soils, cobbles, and shallow depth to bedrock, that restrict bioturbation (the churning of soil by an organism) by fossorial rodents. *Texosporium* and the federally-listed endan-

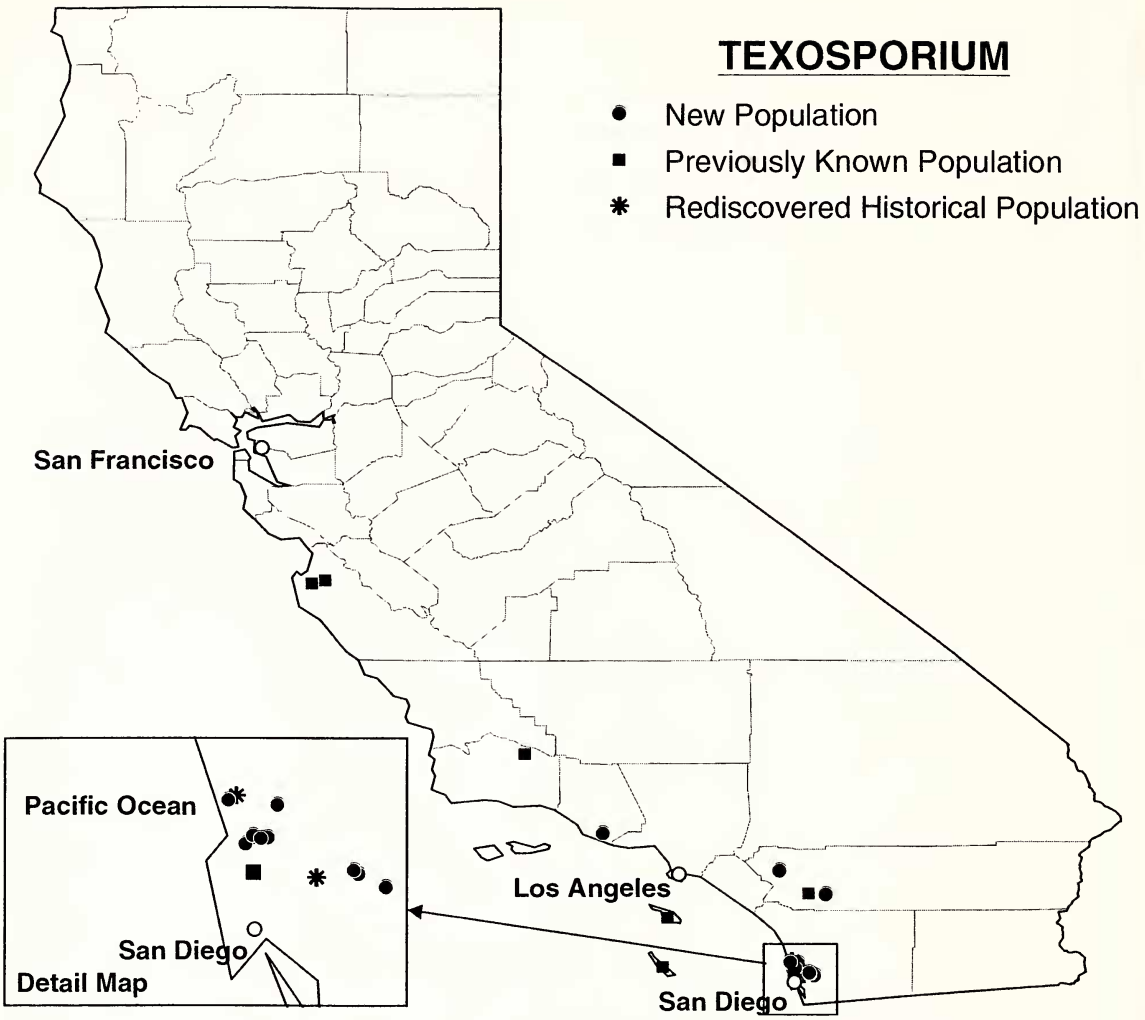

FIG. 1. Known distribution of *Texosporium sancti-jacobi.* Solid circles indicate populations confirmed in the last few years. Squares indicate previously known populations, including two offshore islands, Santa Catalina Island and San Clemente Island. Inset shows the distribution in San Diego County. An asterisk indicates the two historical populations at Del Mar and Kearny Mesa rediscovered during this study. The map was developed from an ESRI base map.

gered quino checkerspot butterfly ("QCB," *Euphydryas editha quino* [Behr]) share similar open-habitat soils (Riefner et al. 2002), including several currently occupied or historical localities of the butterfly reported by Mattoni et al. (1997). Continuing surveys are warranted for *Texosporium* at other QCB sites, and in similar habitats throughout southern and central California.

Old rabbit pellets are the preferred substrate for *Texosporium* in southern California. On mesas in the coastal fog belt of San Diego County, rabbit pellets with *Texosporium* are often intimately associated with mats of mesa spike-moss (*Selaginella cinerascens*) or crust organisms that stabilize the soil surface and provide open habitats with microclimate conditions that promote rapid surface drying of organic material. The Lindavista Formation underlies many of the San Diego populations. Well-drained loams with an underlying silcrete duripan, and assemblages of mima mounds and vernal pools are characteristic of the Formation (Bowman 1973). Rabbits have been identified as dispersal vectors of some vascular plants in these landscapes (Zedler and Black 1992), and may play an important role in the dispersal and ecology of *Texosporium. Texosporium* spores may be able to pass thru the gut of rabbits unharmed due to their surface ornamentation that mimic a seed coat (McCune and Rosentreter 1992), and may also allow for spore survival in arid habitats.

Accordingly, these interacting components apparently account for the relatively high concentration of *Texosporium* in the San Diego area. Even in the less coastally influenced climate of western Riverside County, the preferred habitat for *Texosporium* are open micro-sites associated with coarse

grüs (granitic) substrates that weather to form fine-grained thin argillic (claypan) horizons, which also allow for rapid wetting and drying of organic matter. These soils restrict perennial vascular plant development (Knecht 1971), stabilize decaying organic matter, and provide extensive open habitats with native forbs favorable for rabbits. *Texosporium* is rare in Ventura County on Igneous Rock Land (IrG), which consists of basalt, andesite, and volcanic breccia outcroppings with a thin mantle of relatively stable soil material that is typically barren or has only a sparse brush cover (Edwards et al. 1970). This igneous bedrock is similar to the habitats where *Texosporium* occurs in the drier cold desert of the Great Basin habitats in Idaho and Oregon. In these habitats, the preferred substrate for *Texosporium* appears to switch to larger clumps of organic matter such as dead bunchgrass clumps that are embedded in silty soils. These sites support open shrub communities where the shrubs capture drifting snow and provide protection from drying winds of the desert. *Texosporium* does not occur on rabbit pellets in these Great Basin habitats.

In all known geographic regions, *Texosporium* prefers non-calcareous substrates, fine-textured non-woody organic matter that slowly accumulates on soil in sunny open habitats sparsely vegetated with native plants that have minimal signs of recent disturbance. Most sites are considered late successional or old growth habitats. *Texosporium,* therefore, can be considered an ecologically significant indicator of relatively undisturbed shrub-steppe, grassland, and savanna communities. In all regions *Texosporium* is associated with a well-developed biological soil crust although the specific taxa composing the crusts differ according to region. At the Pinnacles National Monument, and in Santa Barbara County, *Texosporium* is associated with *Aspicillia californica* Rosentreter (Bratt 2002). In western Riverside County and Ventura County, it is intimately associated with another uncommon lichen, *Acarospora thelococcoides* (Nyl.) Zahlbr., which is also a potential indicator of open-habitat soils used by QCB (RER, personal observation). With the exception of the Riverside County localities, *Caloplaca* cf. *subpyraceella* (Nyl.) Zahlbr. shares identical habitats and substrates at all south coast *Texosporium* populations. Bryophytes are also an important component of these habitats, which often include *Asterella californica* (Hampe) Underw., *Bryum argenteum* Hedw., *Didymodon vinealis* (Brid.) Zander, *Funaria hygrometrica* Hedw., *Riccia nigrella* Lam., *R. trichocarpa* Howe, and *Tortula* sp.

Ware (2002) reviewed the ecology of "glades" and pointed out the importance of preserving shallow-soil plant communities in the eastern United States. In California, weathered duripan soils have received conservation attention because of vernal pools. However, upland habitats around vernal pools (Holstein 2001), and other shallow soil and open micro-site habitats that support biological crusts, and small native annual dicots and invertebrates have been largely ignored. The Endangered Species Act provides an "animal umbrella of protection" that preserves a small number of *Texosporium*'s microhabitats used by QCB in western Riverside County. Because QCB has been extirpated throughout most of its range, many *Texosporium* populations in other counties are not directly linked to this listed species. Accordingly, preservation of undisturbed open-habitat soils must become a focus of conservation activities if *Texosporium* and other rare biological crust organisms, including the liverworts *Geothallus tuberosus* Campb. and *Spaerocarpos drewei* Wigglesw. (CNPS 2001), are to persist in southern California.

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